**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BOARD OF PATENT APPEALS AND INTERFERENCES**

In re Patent Application of:	Bruce H. Storm Jr., et al.
Serial No.:	10/051,323
Filed:	January 18, 2002
Entitled:	FIELD/RESERVOIR OPTIMIZATION UTILIZING NEURAL NETWORKS
Group Art Unit:	2121
Examiner:	G. Davis

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APPEAL BRIEF

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Appellants hereby timely submit this Appeal Brief in triplicate under the provisions of 37 CFR §1.192(a) and respectfully request consideration thereof before the Board of Patent Appeals and Interferences. Appellants' Notice of Appeal was filed on April 2, 2004, appealing to the Board from the decision of the examiner, mailed February 9, 2004, finally rejecting all of the pending claims of the above-identified patent application.

A check in the amount of $330.00 is enclosed herewith in payment of the fee specified in 37 CFR §1.17(c).

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REAL PARTY IN INTEREST

The real party in interest is the assignee of the present application, Halliburton Energy Services, Inc. of Dallas, Texas.

RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences known to appellants, the appellants' legal representatives or assignee which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

STATUS OF CLAIMS

Claims 1-16 were originally filed in the present application. Claim 5 has been canceled. No claims have been added. Each of the presently pending claims 1-4 and 6-16 has been rejected twice, and these rejections are appealed.

STATUS OF AMENDMENTS

An Amendment was filed on November 12, 2003, subsequent to a non-final May 28, 2003 Office Action. The claims as set forth in Appendix A include changes to the claims made according to the Amendment, which was entered by the examiner.

SUMMARY OF THE INVENTION

The present invention advances the art of optimizing performance of a well system. A neural network is trained using parameters which influence an output of the well system, as well as parameters which are indicative of the well system output. The neural network is trained until it acceptably models the output of the well system in response to input thereto of the influencing parameters.

Prospective influencing parameters (such as prospective positions of production valves) are then input to the trained neural network. The neural network in response predicts outputs of the well system. The predicted well system outputs are then input to a reservoir or geologic model, which predicts the effects of the well system outputs on the reservoirs. The predicted reservoir effects output by the reservoir model are then input to a financial model, which predicts a net present value (NPV).

In this manner, an operator of the well system can immediately predict how a prospective change in influencing parameters will affect the NPV of the well system. This will provide the operator with the information needed to determine whether the prospective change should be carried out. Furthermore, numerical optimization techniques can be utilized to determine how the influencing parameters can be adjusted to maximize the NPV of the well system. This will provide the operator with the information needed to determine how the influencing parameters could be changed to maximize the well system NPV.

ISSUES

Whether claims 1-4 and 6-16 are properly rejected under 35 USC §102(b) as being anticipated by an alleged admission made in the specification.

Whether claims 1-4 and 6-16 are properly rejected under 35 USC §102(a) as being anticipated by Yang, et al., "A Neural Network Approach to Predict Existing and In-Fill Oil Well Performance," IEEE, IJCNN, July 2000 (hereinafter, Yang).

GROUPING OF CLAIMS

Claims 1 and 4 stand or fall together.

Claims 9 and 10 stand or fall together.

Claims 12 and 13 stand or fall together.

Each of the remaining claims stands on its own recitation, and each claim is considered separately patentable for reasons set forth in more detail below.

ARGUMENT

Rejections under 35 USC §102(b)

In paragraph 1 of the final Office Action, the examiner states that, "Applicant admits training neural network with input parameters is well known in the art (see specification, page 6, lines 20 and 21)." Of course it is well known to train neural networks using input parameters! The appellants even list

several known training methods (e.g., a back propagation algorithm, the special algorithms used to train Hopfield and Kohonen networks, etc.) in the paragraph following the alleged admission in the specification.

However, the present application is not directed to neural network training algorithms. Instead, the present application is directed to methods of optimizing performance of a well system. As outlined in the Summary above, training the neural network is only an initial part of the claimed methods, which are repeatedly identified in the specification as being inventive, as embodying principles of the invention and as being advancements in the art.

On page 3, lines 15 and 16, FIG. 1 is described as illustrating a method embodying principles of the invention. On page 3, lines 20 and 21, FIG. 5 is described as illustrating a method embodying principles of the invention. On page 3, lines 25 and 26, the applicants state that the method 10 embodies principles of the invention. On page 4, lines 7-9, the applicants state that the method 10 is merely an example of a wide variety of methods which may incorporate the principles of the invention. On page 8, lines 8 and 9, the applicants state that the method 40 embodies principles of the present invention. In the Summary section of the specification, various inventive aspects and advantages of the invention are identified.

Thus, rather than admit that the methods disclosed in the specification are old in the art, the applicants have clearly indicated in no uncertain terms that these methods are indeed inventive. <u>How the examiner can take a simple</u>

statement that neural network training methods are known to those skilled in the art, and turn it into an admission that every method disclosed in the specification is old in the art is unfathomable to the applicants. However, an attempt will be made below to show that each claim of the application recites at lest one feature of the invention not included in the neural network training methods known to those skilled in the art prior to the applicants' invention.

Claim 1 recites a step of inputting an output of the trained neural network to a geologic model. The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 1.

Claim 2 is dependent from claim 1 and, thus, the reasons given above for the impropriety of the rejection of claim 1 also apply to the rejection of claim 2. Furthermore, claim 2 recites a step of the trained neural network outputting the indicative parameters in response to input of the respective influencing parameters to the neural network. The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 2.

Claim 3 is dependent from claim 1 and, thus, the reasons given above for the impropriety of the rejection of claim 1 also apply to the rejection of claim 3.

Furthermore, claim 3 recites <u>a data set accumulating step wherein the influencing parameters include valve positions.</u> The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 3.

<u>Claim 4</u> is dependent from claim 1 and, thus, the reasons given above for the impropriety of the rejection of claim 1 also apply to the rejection of claim 4. Furthermore, claim 4 recites <u>a data set accumulating step wherein the indicative parameters include production rates.</u> The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 4.

<u>Claim 6</u> is dependent from claim 1 and, thus, the reasons given above for the impropriety of the rejection of claim 1 also apply to the rejection of claim 6. Furthermore, claim 6 recites a step of <u>inputting an output of the geologic model to a financial model</u>. The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 6.

Claim 7 is dependent from claim 6 and, thus, the reasons given above for the impropriety of the rejections of claims 1 and 6 also apply to the rejection of claim 7. Furthermore, claim 7 recites a step of <u>optimizing an output of the financial model in response to input of prospective influencing parameters to the neural network.</u> The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 7.

Claim 8 is dependent from claim 7 and, thus, the reasons given above for the impropriety of the rejections of claims 1, 6 and 7 also apply to the rejection of claim 8. Furthermore, claim 8 recites that <u>the optimizing step further comprises determining a respective value for each of the prospective influencing parameters, whereby the output of the financial model in response to input of the prospective influencing parameters to the neural network is optimized</u>. The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 8.

Claim 9 recites the steps of <u>inputting an output of the neural network to at least one valuing model, and optimizing an output of the valuing model in response to input of the well system parameter to the neural network.</u> The applicants have clearly not admitted that these steps are part of any neural

network training method known to those skilled in the art prior to the applicants' invention. Therefore, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 9.

Claim 10 is dependent from claim 9 and, thus, the reasons given above for the impropriety of the rejection of claim 9 also apply to the rejection of claim 10. Furthermore, claim 10 recites that the training step further comprises inputting multiple training data sets to the neural network, each of the data sets including at least one known parameter influencing the well system output. The applicants have clearly not admitted that the invention recited in claim 10 is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 10.

Claim 11 is dependent from claim 10 and, thus, the reasons given above for the impropriety of the rejections of claims 9 and 10 also apply to the rejection of claim 11. Furthermore, claim 11 recites that in the training step, the known influencing parameter is a position of a valve in the well system. The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 11.

Claim 12 is dependent from claim 10 and, thus, the reasons given above for the impropriety of the rejections of claims 9 and 10 also apply to the rejection of claim 12. Furthermore, claim 12 recites that the training step further comprises training the neural network to output at least one known parameter indicative of the well system output in response to the input to the neural network of the known influencing parameter. The applicants have clearly not admitted that the method recited in claim 12 is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 12.

Claim 13 is dependent from claim 12 and, thus, the reasons given above for the impropriety of the rejections of claims 9, 10 and 12 also apply to the rejection of claim 13. Furthermore, claim 13 recites that in the training step the known indicative parameter is a production rate in the well system. The applicants have clearly not admitted that the method recited in claim 13 is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 13.

Claim 14 is dependent from claim 9 and, thus, the reasons given above for the impropriety of the rejection of claim 9 also apply to the rejection of claim 14. Furthermore, claim 14 recites that the valuing model includes a geologic model and a financial model. The applicants have clearly not admitted that this step is

part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 14.

Claim 15 is dependent from claim 14 and, thus, the reasons given above for the impropriety of the rejections of claims 9 and 14 also apply to the rejection of claim 15. Furthermore, claim 15 recites that the output of the neural network is input to the geologic model, and an output of the geologic model is input to the financial model. The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 15.

Claim 16 is dependent from claim 9 and, thus, the reasons given above for the impropriety of the rejection of claim 9 also apply to the rejection of claim 16. Furthermore, claim 16 recites that the well system parameter is varied to maximize the valuing model output. The applicants have clearly not admitted that this step is part of any neural network training method known to those skilled in the art prior to the applicants' invention. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 16.

In addition, the examiner has rejected claims 1-4 and 6-16 under 35 USC §102(b), which requires that the invention be <u>patented</u>, <u>described in a printed publication</u>, <u>in public use</u>, or <u>on sale more than one year prior to the date of application for patent</u>. Clearly, the applicants have not admitted that the invention was <u>patented</u>. Likewise, the applicants have not admitted that the invention was <u>described in a printed publication</u>. Nor have the applicants admitted that the invention was <u>in public use</u>. Similarly, the applicants have not admitted that the invention was <u>on sale</u>.

Without question, the applicants have not admitted that any of these activities occurred <u>more than one year prior to the date of application for patent</u>. It is unclear how the examiner is using 35 USC §102(b) to reject any of the claims in the present application, given that <u>not one</u> of the requirements of that statutory provision is applicable. Thus, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw these rejections of claims 1-4 and 6-16.

Rejections under 35 USC §102(a)

Each of claims 1-4 and 6-16 is rejected as being anticipated by the published article of Yang. This article does indeed describe the training of a neural network in the general field of well production prediction. However, the method described by Yang is very different from the methods claimed in the present application.

This is to be expected, since Yang's intent is to predict existing wells' future production performance without using reservoir data, which is difficult to determine and often unavailable (Yang, paragraph 3 of Introduction, page 408). Another purpose expressed by Yang is to optimize the location of an infill well (Yang, last sentence of Abstract on page 408, and Case 3 on page 412). Note that Yang does not actually describe how to optimize the location of an infill well, instead Yang merely describes this as an objective for the future. What Yang does describe in Case 3 of the article is use of a neural network to predict performance of an infill well at a certain location.

Yang certainly does not describe the methods claimed in the present application. In fact, Yang in some instances teaches away from the methods recited in the claims. For example, Yang eschews the use of reservoir data (which is difficult to determine and often unavailable, according to Yang), choosing instead to base training of a neural network on historical production data to merely generate a projection of existing wells' future production performance.

Claims 1 and 4 recite that a method of optimizing performance of a well system includes the step of inputting an output of the trained neural network to a geologic model. This step is not described in the Yang reference. In fact, the term "geologic model" is not mentioned at all in the Yang reference. Yang does mention use of reservoir data (formation permeability, oil viscosity, etc.) in the past to develop equations to predict well production (Yang, paragraph 3 of Introduction, page 408).

However, Yang clearly teaches away from the use of reservoir data (which is difficult to determine and often unavailable, according to Yang). Even if Yang did teach the use of reservoir data to train a neural network, this still is quite different from the step recited in claim 1 of inputting an output of the trained neural network to a geologic model. Since Yang does not describe, or even suggest, this step recited in claim 1, Yang clearly does not anticipate claim 1 or any of its dependents (including claim 4). Therefore, the Board is respectfully requested to direct the examiner to withdraw these rejections of claims 1 and 4.

Claim 2 is dependent from claim 1 and, thus, the reasons given above for the impropriety of the rejection of claim 1 also apply to the rejection of claim 2. Furthermore, claim 2 recites that the training step includes outputting the indicative parameters in response to input of respective influencing parameters to the neural network. Yang is unclear on whether or not this step is performed.

Table 1 on page 410 of Yang shows that both indicative parameters (e.g., cumulative production) and influencing parameters (e.g., average distance to surrounding wells) are input to the neural network, but Yang does not describe outputting the indicative parameters in response to input of respective influencing parameters to the trained neural network. Since Yang does not describe this step, Yang cannot anticipate claim 2. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 2.

Claim 3 is dependent from claim 1 and, thus, the reasons given above for the impropriety of the rejection of claim 1 also apply to the rejection of claim 3. Furthermore, claim 3 recites that in the data set accumulating step, the influencing parameters include valve positions. Yang does not describe the use of valve positions in data sets used to train a neural network.

The word "valve" is not found at all in the Yang reference, much less the use of valve positions as well performance influencing parameters in training a neural network. Since Yang does not describe this step, Yang cannot anticipate claim 3. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 3.

Claim 6 is dependent from claim 1 and, thus, the reasons given above for the impropriety of the rejection of claim 1 also apply to the rejection of claim 6. Furthermore, claim 6 recites the step of inputting an output of the geologic model to a financial model. As discussed above, Yang teaches away from the use of reservoir data and does not even mention the use of a geologic model.

Similarly, there is no mention in Yang of the term "financial model" or of using a financial model in a well system performance optimizing method. Yang also does not describe inputting an output of a geologic model to a financial model. Since Yang in no way describes this step, Yang cannot anticipate claim 6. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 6.

Claim 7 is dependent from claim 6 and, thus, the reasons given above for the impropriety of the rejections of claims 1 and 6 also apply to the rejection of claim 7. Furthermore, claim 7 recites the step of optimizing an output of the financial model in response to input of prospective influencing parameters to the neural network. Yang does not describe use of a financial model, as discussed above. Yang also does not describe optimizing an output of a financial model. Yang also does not describe the input of prospective influencing parameters to the neural network. Instead, Yang only uses historical data as inputs to a neural network. Yang also does not describe financial model optimization in response to the input of prospective influencing parameters.

Since Yang in no way describes this step, Yang cannot anticipate claim 7. Therefore, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 7.

Claim 8 is dependent from claim 7 and, thus, the reasons given above for the impropriety of the rejections of claims 1, 6 and 7 also apply to the rejection of claim 8. Furthermore, claim 8 recites that the optimizing step includes determining a respective value for each of the prospective influencing parameters, whereby the output of the financial model in response to input of the prospective influencing parameters to the neural network is optimized. As discussed above, Yang does not describe use of a financial model, optimization of a financial model, or the use of prospective influencing parameters in financial model optimization at all.

Similarly, Yang does not describe how respective values of the prospective influencing parameters can be determined to optimize the output of the financial model. Since Yang in no way describes this step, Yang cannot anticipate claim 8. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 8.

Claims 9 and 10 recite a method of optimizing performance of a well system which includes the steps of inputting an output of a neural network to at least one valuing model, and optimizing an output of the valuing model in response to input of a well system parameter to the neural network. Yang does not describe use of a valuing model at all. Yang also does not describe optimizing an output of a valuing model. Yang only describes a hope in the future of developing a method of optimizing a location of an infill well.

Similarly, Yang does not describe inputting an output of a neural network to a valuing model, or optimizing the output of the valuing model in response to input of a well system parameter to the neural network. Since Yang in no way describes these several features recited in claim 9, Yang clearly cannot anticipate claim 9 or any of its dependents (including claim 10). Therefore, the Board is respectfully requested to direct the examiner to withdraw these rejections of claims 9 and 10.

Claim 11 is dependent from claim 10 and, thus, the reasons given above for the impropriety of the rejections of claims 1 and 10 also apply to the rejection of claim 11. Furthermore, claim 11 recites that the known influencing

parameter in the training step is a position of a valve in the well system. As noted above, the word "valve" does not even appear in the Yang reference.

In addition, Yang does not describe use of a valve position as a known influencing parameter in a neural network training step. Since Yang in no way describes these features of claim 11, Yang cannot anticipate claim 11. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 11.

Claims 12 and 13 are dependent from claim 10 and, thus, the reasons given above for the impropriety of the rejections of claims 1 and 10 also apply to the rejections of claims 12 and 13. Furthermore, claim 12 recites training the neural network to output at least one known parameter indicative of the well system output in response to the input to the neural network of the known influencing parameter. As discussed above in relation to the rejection of claim 2, Yang is unclear on the actual steps used to train the neural network.

In addition, claim 13 recites that the known indicative parameter is a production rate in the well system. Yang describes use of cumulative production, but not production rate. Therefore, Yang does not anticipate claim 12 or 13. The Board is respectfully requested to direct the examiner to withdraw these rejections of claims 12 and 13.

Claim 14 is dependent from claim 9 and, thus, the reasons given above for the impropriety of the rejection of claim 9 also apply to the rejection of claim 14. Furthermore, claim 14 recites that the valuing model includes a geologic model

and a financial model. As discussed above, Yang does not describe use of a geologic model, and Yang does not describe use of a financial model.

Since Yang does not describe the features recited in claim 14, Yang cannot anticipate claim 14. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 14.

Claim 15 is dependent from claim 14 and, thus, the reasons given above for the impropriety of the rejections of claims 1 and 14 also apply to the rejection of claim 15. Furthermore, claim 15 recites that the output of the neural network is input to the geologic model, and an output of the geologic model is input to the financial model. Yang does not describe inputting an output of a neural network to a geologic model. Yang also does not describe inputting an output of the geologic model to a financial model.

Yang does not describe use of a geologic model or a financial model at all. Since Yang does not describe these features recited in claim 15, Yang cannot anticipate claim 15. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 15.

Claim 16 is dependent from claim 9 and, thus, the reasons given above for the impropriety of the rejection of claim 9 also apply to the rejection of claim 16. Furthermore, claim 16 recites that the optimizing step includes varying the well system parameter to maximize the valuing model output. Yang does not

describe varying a well system parameter which is input to a neural network. Instead, Yang uses historical data, which includes parameters which are not varied (since they are historical), as inputs to the neural network.

Yang also does not describe varying a well system parameter to maximize a valuing model output. As discussed above, Yang does not describe use of a valuing model at all, much less maximizing a valuing model output. Since Yang does not describe these features recited in claim 16, Yang cannot anticipate claim 16. Therefore, for this additional reason, the Board is respectfully requested to direct the examiner to withdraw this rejection of claim 16.

CONCLUSION

For the foregoing reasons, it is submitted that the examiner's rejections of claims 1-4 and 6-16 in the final Office Action are in error, and reversal of the examiner's decisions is respectfully requested.
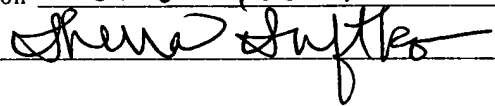
Respectfully submitted,

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APPENDIX A

[The claims as rejected]

1.   A method of optimizing performance of a well system, the method comprising the steps of:

accumulating multiple data sets, each data set including at least one parameter influencing an output of the well system, and at least one parameter indicative of the well system output;

training a neural network to model the output of the well system in response to the influencing parameters; and

inputting an output of the trained neural network to a geologic model.

2.   The method according to Claim 1, wherein the training step further comprises training the neural network utilizing the data sets, the trained neural network outputting the indicative parameters in response to input of the respective influencing parameters to the neural network.

3.   The method according to Claim 1, wherein in the accumulating step, the influencing parameters include valve positions.

4.   The method according to Claim 1, wherein in the accumulating step, the indicative parameters include production rates.

5. (canceled)

6.   The method according to Claim 1, further comprising the step of inputting an output of the geologic model to a financial model.

7.   The method according to Claim 6, further comprising the step of optimizing an output of the financial model in response to input of prospective influencing parameters to the neural network.

8.   The method according to Claim 7, wherein the optimizing step further comprises determining a respective value for each of the prospective influencing parameters, whereby the output of the financial model in response to input of the prospective influencing parameters to the neural network is optimized.

9.   A method of optimizing performance of a well system, the method comprising the steps of:

training a neural network to model an output of the well system in response to at least one variable parameter of the well system;

inputting an output of the neural network to at least one valuing model; and

optimizing an output of the valuing model in response to input of the well system parameter to the neural network.

10. The method according to Claim 9, wherein the training step further comprises inputting multiple data sets to the neural network, each of the data sets including at least one known parameter influencing the well system output.

11. The method according to Claim 10, wherein in the training step, the known influencing parameter is a position of a valve in the well system.

12. The method according to Claim 10, wherein the training step further comprises training the neural network to output at least one known parameter indicative of the well system output in response to the input to the neural network of the known influencing parameter.

13. The method according to Claim 12, wherein in the training step, the known indicative parameter is a production rate in the well system.

14. The method according to Claim 9, wherein in the inputting step, the at least one valuing model includes a geologic model and a financial model.

15. The method according to Claim 14, wherein in the inputting step, the output of the neural network is input to the geologic model, and an output of the geologic model is input to the financial model.

16. The method according to Claim 9, wherein in the optimizing step, the well system parameter is varied to maximize the valuing model output.